Table 18. Mean Tree Seedling Survival and Growth by Fertilization Treatment, with t-tests for Significant Differences in Growth Rates

Species	Survival (%)		Annual Growth (Inches)		
	Unfert.	Fert.	Unfert.	Fert.	t[a]
North Florida slash pine	63.3	47.5	11.8	12.1	0.32
South Florida slash pine	27.0	27.8	5.4	4.9	0.57
Sand pine	51.7	45.6	10.7	12.0	1.18
Loblolly pine	44.3	37.9	12.7	13.3	0.56
Longleaf pine	2.5	1.5	0	0	-
Spruce Pine	59.7	58.8	11.3	10.5	1.02
Cottonwood	8.0	7.7	12.2	16.0	0.82
Bald cypress	81.6	83.2	8.7	8.1	1.21
Catalpa	72.5	65.7	9.6	10.5	0.73
Green Ash	69.4	69.3	2.5	3.0	1.61
Live oak	26.0	23.5	8.7	9.7	0.58
Red cedar	78.1	66.2	18.4	19.1	0.93
Red maple	51.9	51.7	1.2	1.7	1.84
Sweetgum	60.3	53.3	2.0	2.7	1.89
Sycamore	66.8	60.7	9.4	11.8	2.29
Tupelo Gum	26.5	24.0	7.8	8.8	1.21

[a] T-tests were based on differences in overall growth between fertilization classes; unequal variances between classes assumed; significance level is 0.05.

Table 19. Average Tree Seedling Growth (Inches) and its Relation to Elevation for the Year Ending July 1980

Species	Overall	Plot Specific Min.	Plot Specific Max.	Elevation Effect (R^2)[a]
North Florida slash pine	11.9	7.6	16.5	0.31
South Florida slash pine	5.1	4.5	6.3	0.04
Sand pine	11.3	10.3	12.6	0.10
Loblolly pine	13.0	10.3	15.4	0.12
Longleaf pine	0	0	0	-
Spruce pine	10.9	8.4	12.4	0.04
Cottonwood	14.1	-2.3	21.3	0.61
Bald cypress	8.4	2.4	14.9	0.89
Catalpa	10.0	0.6	13.4	0.57
Green ash	2.8	0.1	8.2	0.53
Live oak	9.2	7.3	11.7	0.07
Red cedar	18.8	17.4	19.7	0.30
Red maple	1.5	-1.1	4.8	0.59
Sweetgum	2.3	-1.8	9.2	0.45
Sycamore	10.5	9.6	11.6	0.01
Tupelo Gum	8.3	3.0	11.7	0.76

[a] values represent the percent of the variation in growth explainable by planting elevation using a quadratic model (i.e. growth = elevation + $elevation^2$); values for models deemed significant (0.05 or better) by F test.

Table 20. Significant Quadratic Model Predictions of Maximum Growth for Five Seedling Species Planted Within the Zone of Inundation

Species	Elevation Range[a] Min.	Elevation Range[a] Max.	Predicted[b] Max. Growth	Predicted[b] Elev.	Inun.
Bald cypress	87.5	90.5	15.0	87.5	90.1
Green Ash	87.5	90.5	4.7	87.5	90.1
Red Maple	87.5	97.0	6.0	97.0	0
Sweetgum	87.4	96.0	7.0	96.0	0
Tupelo Gum	87.5	90.4	11.3	87.5	90.1

[a] Actual range of elevations within which the species was planted.

[b] Model prediction of the maximum growth rate in inches, the elevation of maximum height growth and corresponding inundation percentage.

To rate their relative performance, each species was ranked according to its maximum, plot-specific survival and growth (Table 21). Plot-specific values were used in order to minimize the effect of planting location on observed success. Bald cypress ranked first overall and had the highest survival rate. The fastest grower was cottonwood; however, it only ranked eighth overall because of its relatively poor survival. The lowest performances were observed for longleaf pine, south Florida slash pine, live oak and red maple - four of the most prevalent species in central Florida.

Table 21. Relative Ranking of Seedling Species Planted Based on their Maximum Plot-Specific Survival and Growth

Species	Rankings		
	Growth	Survival	Overall
Bald Cypress	5	1	1
Red Cedar	2	7	2
Catalpa	6	5	3
Spruce Pine	8	3	4
North Florida Slash Pine	3	9	5
Loblolly Pine	4	11	6
Green Ash	13	2	7
Cottonwood	1	15	8
Sweetgum	12	4	9
Sand Pine	7	12	10
Sycamore	11	8	11
Tupelo Gum	9	10	12
Red Maple	15	6	13
Live Oak	10	13	14
South Florida Slash Pine	14	14	15
Longleaf Pine	16	16	16

Tree Transplants. Midway through their second summer (July 1980), 82 of the 104 trees moved onto the site were still living (overall survival of 78.8 percent). Of these, 38 were in relatively good condition, 33 were fair and 11 were poor (Table 22). None of the trees however, had completely overcome the stress of transplanting since all were noticeably less vigorous than their counterparts in the surrounding floodplain. Cabbage palm was the least successful species with only one of eight surviving. There was no apparent difference in success with regard to planting location.

Table 22. Survival and Condition of Trees Transplanted onto the Test Site from the Peace River floodplain

			Condition				
Species	Total Planted	Planting Location	Good	Fair	Poor	Dead	% Surv.
Bald cypress	12	W	6	4	0	2	83.3
Black cherry	1	U	1	0	0	0	100.0
Cabbage palm	8	U	0	0	1	7	12.5
Florida elm	12	U,W	6	4	1	1	91.7
Ironwood	1	U	0	1	0	0	100.0
Laurel oak	6	U	1	2	1	2	66.7
Persimmon	2	U	0	0	2	0	100.0
Pignut hickory	2	U	2	0	0	0	100.0
Red maple	8	U,W	1	4	1	2	75.0
Sugarberry	3	U	2	1	0	0	100.0
Sweetgum	17	U	3	9	2	3	82.3
Pop ash	21	W	12	7	1	1	95.2
Water oak	11	U	4	1	2	4	63.6

[a] Refers to onsite planting location; either in the upland (U) (non-inundated areas); or the wetland (W) (periodically inundated zone).

CLAY SETTLING AREAS

Over the course of study, 124 species were observed, which included 8 mammals, 97 birds, 15 reptiles and 4 amphibians (Table 23). Seven are considered as either endangered (wood stork), threatened (bald eagle and least tern) or of special concern (little blue heron, Louisiana heron, snowy egret and American alligator) by the Florida Game and Fresh Water Fish Commission, while one is listed as endangered (bald eagle) and another is considered threatened (American alligator) by the U.S. Fish and Wildlife Service. The most conspicuous use of the study areas was as wintering habitat for migratory birds, especially waterfowl. Local wading birds and other wetland and aquatic species however, showed a sustained use through the period of study.

The bird surveys produced 154,708 observations of individuals classified according to species (or family group if unidentifiable in the field) and according to the habitat or combination of habitats being utilized (Table 24). Coots, ruddy ducks, shovelers, blue-winged teal and swallows were the most abundant with over 10,000 sightings each. Other common species or groups having close to 1,000 or more sightings were double-crested cormorants, red-winged blackbirds, sandpipers, ring-necked ducks, ring-billed gulls, boat-tailed grackles, snowy egrets, pied-billed grebes, great egrets, anhingas, white pelicans, common gallinules and green-winged teal.

The area-wide surveys recorded a combined average of 36 observations per minute through the course of study. Peak use was in January (53 per minute) while the low was in June (9 per minute) (Figure 29). The highest total count was 8,145 (136 per minute), observed on November 2, 1979 in a 425 acre supplemental area (shallow water, approximately 20 percent vegetated). Area E had the highest observed use of the five study areas, averaging 50 sightings per minute overall. Its largest total count was 4,589 (102 per minute), observed on February 5, 1980, while its lowest total of 289 sightings (14 per minute) was made on June 10, 1980. Area B, the most thoroughly vegetated area, had the lowest rate of observed use, averaging about four sightings per minute.

The apparent trend in area-wide use for the five study areas indicates a decreasing habitat value with increasing area age or successional development. With the exception of area A (the oldest) sighting efficiency increased in each successively younger area (Figure 30). Site A had apparently succeeded into a willow community several years prior to the study, but its succession had been reversed to a largely open-water setting through use of the area as a water reservoir. Stands of flood stressed willow, a remnant of the former shrub forest community, still occur over about 7 percent of the area (Table 25).

Table 23. Wildlife Species Recorded on Clay Settling Area Study Sites from October 1979 to June 1980

REPTILES & AMPHIBIANS

Alligator
Eastern mud turtle
Peninsular cooter
Florida red-bellied turtle
Florida softshell
Florida green water snake
Banded water snake
Florida watersnake
Eastern garter snake
Peninsula ribbon snake
Southern ringneck snake
Southern black racer
Rough green snake
Yellow rat snake
Florida cottonmouth
Southern toad
Bullfrog
Pigfrog
Southern leopard frog

BIRDS

Eared grebe
Pied-billed grebe
White pelican
Double-crested cormorant
Anhinga
Mallard
Black duck
Florida duck
Pintail
Gadwall
American widgeon
Shoveler
Blue-winged teal
Green-winged teal
Wood duck
Redhead
Canvasback
Ring-necked duck
Lesser scaup
Ruddy duck
Hooded merganser
Turkey Vulture
Black vulture
Sharp-shinned hawk
Marsh hawk
Red-tailed hawk
Red-shouldered hawk
Bald eagle
Osprey
Sparrow hawk
Bobwhite quail
Great egret
Snowy egret
Cattle egret
Great blue heron
Louisiana heron
Little blue heron
Green heron
Black-crowned night heron
American bittern
Least bittern
Wood stork
Glossy ibis
White ibis
Sora rail
King rail
Common gallinule
American coot
American avocet
Black-necked stilt
Killdeer
Greater yellowlegs
Lesser yellowlegs
Short-billed dowitcher
Long-billed dowitcher
Common snipe
Ring-billed gull
Laughing gull
Bonaparte's gull
Least tern
Common tern
Forster's tern
Gull-billed tern
Royal tern
Caspian tern

Table 23 (concluded)

BIRDS

Black tern
Black skimmer
Mourning dove
Ground dove
Smooth-billed ani
Common nighthawk
Belted kingfisher
Eastern kingbird
Eastern phoebe
Barn swallow
Tree swallow
Common crow
Fish crow
House wren
Carolina wren
Long-billed marsh wren
Short-billed marsh wren
Mockingbird
Catbird
Robin
Blue-gray gnatcatcher
Loggerhead shrike
Myrtle warbler
Palm warbler
Yellowthroat
Bobolink
Eastern meadowlark
Red-winged blackbird
Boat-tailed grackle
Cardinal
Rufous-sided towhee
Savannah sparrow
Swamp sparrow
Song sparrow

MAMMALS

Opossum
Raccoon
River otter
Striped skunk
Bobcat
House Mouse
Eastern cottontail
Marsh rabbit

Table 24. Species Totals From all Bird Surveys and Their Frequency of Occurrence[a] by Habitat Type

	Total Observed	Open Water	Hyacinth Mat	Mud Flats	Cattail	Willow Shrub Forest	Spoil Islands w/Trees	Spoil Islands w/o Trees	Flood Stressed Willow
American Avocet	110	100.0	0.0	87.0	0.0	0.0	0.0	0.0	0.0
American Coot	44,002	88.7	27.1	0.1	21.4	0.1	0.0	3.0	6.4
Anhinga	1,598	46.2	4.2	0.0	7.8	0.0	0.0	17.8	78.4
Belted Kingfisher	57	47.4	0.0	0.0	12.3	10.5	0.0	0.0	57.9
Black-Crowned Night Heron	84	10.7	4.8	0.0	78.6	9.5	0.0	3.6	72.6
Black-Necked Stilt	178	34.8	0.6	96.1	0.0	0.0	0.0	2.2	0.0
Black Skimmer	76	59.2	0.0	40.8	0.0	0.0	0.0	59.2	0.0
Black Tern	125	97.6	14.4	2.4	0.0	0.0	0.0	0.0	0.0
Blue-winged Teal	13,804	73.4	45.3	1.6	7.6	0.0	0.0	0.2	0.0
Boat-tailed Grackle	2,246	6.2	53.4	0.0	69.5	15.9	2.3	13.7	22.8
Caspian Tern	74	73.0	0.0	0.0	2.7	0.0	0.0	37.8	0.0
Cattle Egret	685	0.0	15.9	0.0	80.3	1.6	0.0	20.0	0.4
Common Gallinule	1,219	39.5	79.3	5.9	32.3	1.1	0.0	1.1	13.9
Common Yellowthroat	332	0.0	0.0	7.8	94.3	73.8	17.8	0.0	0.3
Double-Crested Cormorant	7,633	80.9	2.0	0.0	0.5	0.0	0.0	53.0	56.4
Dowitcher	371	73.0	0.0	99.5	0.0	0.0	0.0	6.5	0.0
Fish Crow	646	35.4	1.1	0.0	36.7	0.5	0.0	39.5	53.0
Florida Duck	113	93.8	22.1	1.8	2.7	0.0	0.0	19.5	0.0
Forster's Tern	626	89.3	1.9	10.2	0.0	0.0	0.0	0.5	0.0
Gadwall	348	100.0	4.6	0.0	6.0	0.0	0.0	0.0	0.0
Glossy Ibis	173	7.5	60.7	0.6	49.1	0.0	0.0	5.2	1.2
Great Blue Heron	929	29.3	56.5	0.0	69.9	0.8	0.0	25.1	17.1
Great Egret	1,619	21.7	50.5	0.0	74.7	7.7	0.0	21.9	28.9

Table 24. (Concluded)

	Total Observed	Open Water	Hyacinth Mat	Mud Flats	Cattail	Willow Shrub Forest	Spoil Islands w/Trees	Spoil Islands w/o Trees	Flood Stressed Willow
Greater Yellowlegs	169	30.8	6.5	91.1	0.0	0.0	0.0	0.0	0.0
Green Heron	167	7.8	26.9	0.0	62.9	3.6	0.0	0.0	44.9
Green-Winged Teal	1,132	93.4	36.3	0.0	2.5	0.0	0.0	0.0	0.0
Killdeer	65	52.3	0.0	86.2	21.5	0.0	0.0	4.6	0.0
Lesser Scaup	566	100.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
Lesser Yellowlegs	387	67.7	16.5	99.0	0.0	0.0	0.0	0.0	0.0
Little Blue Heron	93	12.9	40.9	1.1	58.1	3.7	1.1	2.2	7.5
Louisiana Heron	283	18.4	64.0	0.0	64.7	1.4	0.7	5.3	2.1
Marsh Hawk	97	17.5	6.2	6.2	85.6	9.3	0.0	0.0	0.0
Mockingbird	50	0.0	0.0	0.0	38.0	50.0	28.0	0.0	0.0
Northern Shoveler	14,934	95.7	12.5	0.9	5.1	0.0	0.0	0.0	0.0
Palm Warbler	544	0.2	0.9	6.1	85.1	56.1	38.4	1.5	0.0
Pied-Billed Grebe	1,654	100.0	4.0	0.0	4.2	0.0	0.0	0.0	0.0
Pintail	98	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Red-Winged Blackbird	6,806	4.9	32.3	0.0	82.3	22.8	4.1	5.4	14.3
Ring-Billed Gull	2,118	96.3	1.2	0.0	0.0	0.0	0.0	52.4	0.2
Ring-necked Duck	5,543	100.0	7.2	0.0	17.6	0.0	0.0	7.4	0.0
Ruddy Duck	21,038	99.1	10.2	0.0	7.9	0.0	0.0	0.0	0.0
Rufous-Sided Towhee	71	0.0	0.0	0.0	70.5	83.7	42.6	9.8	0.0
Sandpiper	5,882	15.4	0.0	100.0	0.3	0.0	0.0	0.0	0.0
Snowy Egret	1,695	28.6	55.9	1.8	80.5	2.4	0.0	12.3	6.1
Swallow	10,949	76.2	14.3	0.7	27.9	2.7	0.2	13.0	12.7
Swamp Sparrow	174	0.0	0.0	5.1	97.7	45.4	5.7	0.0	0.0
White Ibis	173	12.1	63.6	0.0	77.5	0.0	0.0	0.6	0.0
White Pelican	1,526	85.0	3.2	0.0	0.0	0.0	0.0	54.7	2.6
Wood Stork	69	1.4	23.2	0.0	66.7	0.0	0.0	0.0	68.1

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[a] Frequencies do not necessarily total 100 since a species may have been using a multiple of habitat types during a particular survey.

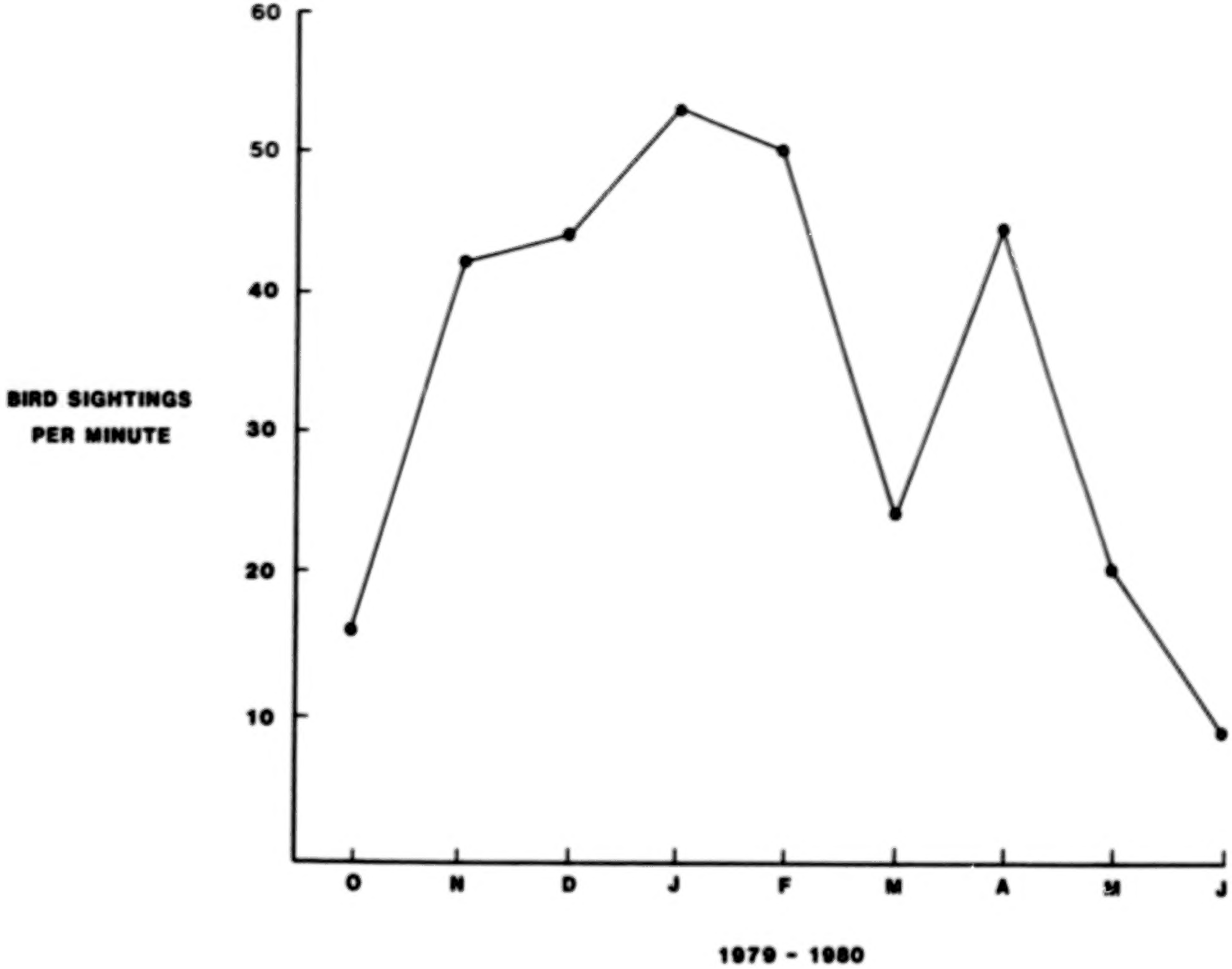

Figure 29. Average number of sightings per minute for all whole area bird surveys from October 1979 to June 1980.

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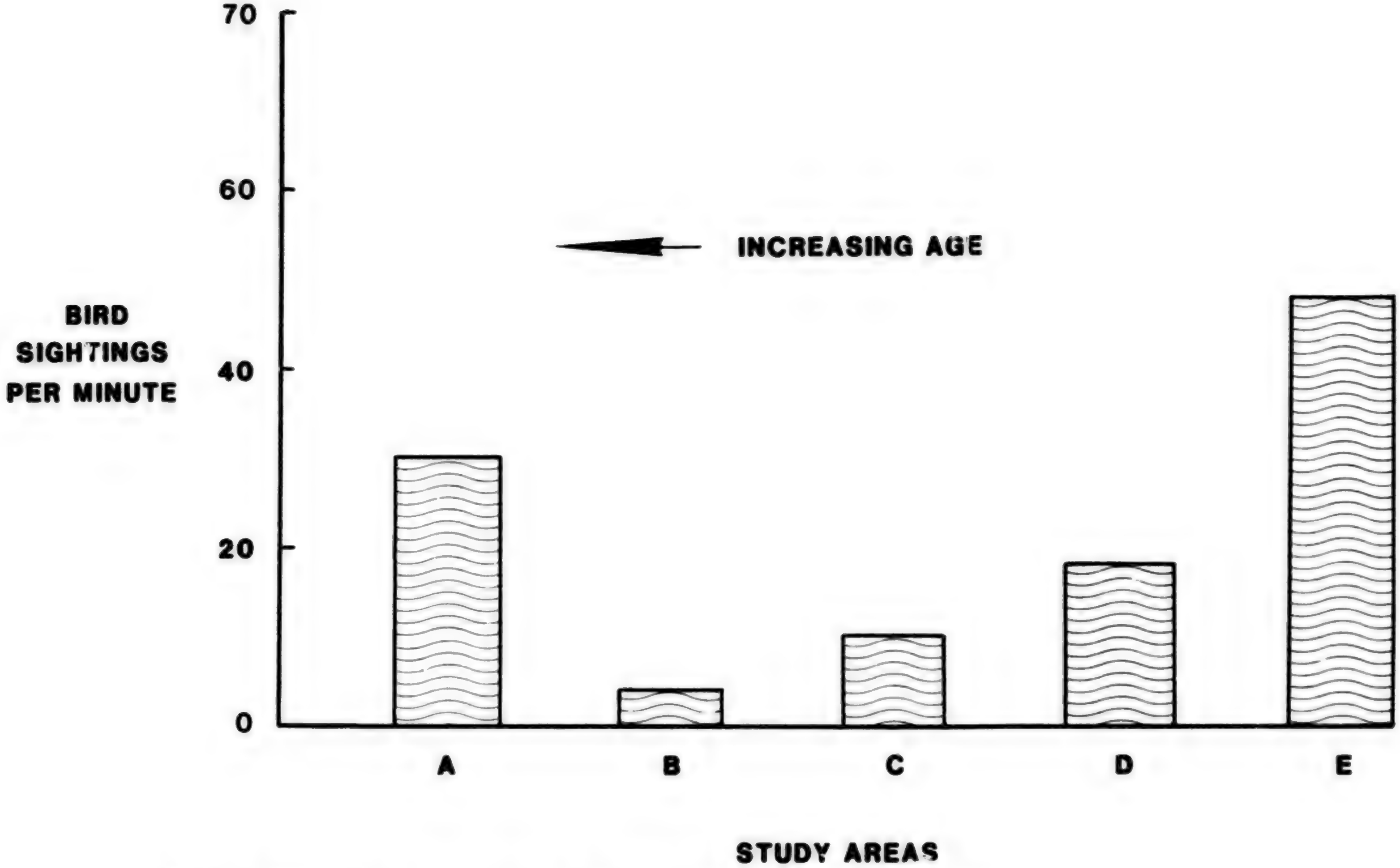

Figure 30. Average number of sightings per minute for each area included in the whole area bird surveys.

Table 25. Acreage and Habitat Type Percentages for Each Study Area and Observation Point Viewing Area

Location		Acreage		Habitat type Percentage					
			O	H	C	W	I	S	U
Area A		295.0	86		4	3	-	7	-
Survey point	1	12.0	45		50	-	-	5	-
	2	54.5	40	5	5	-	-	50	-
	3	60.9	100	-	-	-	-	-	-
Area B		185.0	-	-	16	76	8	-	-
Survey point	1	1.9	-	-	-	50	-	-	50
	2	5.5	-	-	40	60	-	-	-
	3	9.2	-	-	80	15	5	-	-
Area C		306.0	9	16	65	10	-	-	-
Survey point	1	24.5	50	30	20	-	-	-	-
	2	1.7	-	-	70	30	-	-	-
	3	5.9	40	30	30	30	-	-	-
Area D		325.0	8	-	92	-	-	-	-
Survey point	1	6.1	50	10	40	-	-	-	-
	2	5.8	50	25	25	-	-	-	-
	3	6.1	-	-	100	-	-	-	-
Area E		710.0	67	2	30	1	-	-	-
Survey point	1	42.8	85	10	5	-	-	-	-
	2	83.1	100	-	-	-	-	-	-
	3	73.3	85	-	10	-	5	-	-
	4	15.7	15	20	65	-	-	-	-

O = open water
H = water hyacinth covered
C = cattail stands
W = willow shrub forest
I = spoil islands
S = flood stressed willow
U = upland grasses, herbs and low shrubs on consolidated clay

Pooled findings from the observation point surveys showed densities varying significantly on a monthly basis, peaking in December at nine sightings per acre and reaching a low of 1.5 per acre in May (Figure 31). Monthly diversities ranged from a high of 1.23 in February to a low of 0.91 in May, but were not significantly different. These seasonal trends accounted for 12 and 3 percent of the variation in overall density and diversity respectively.

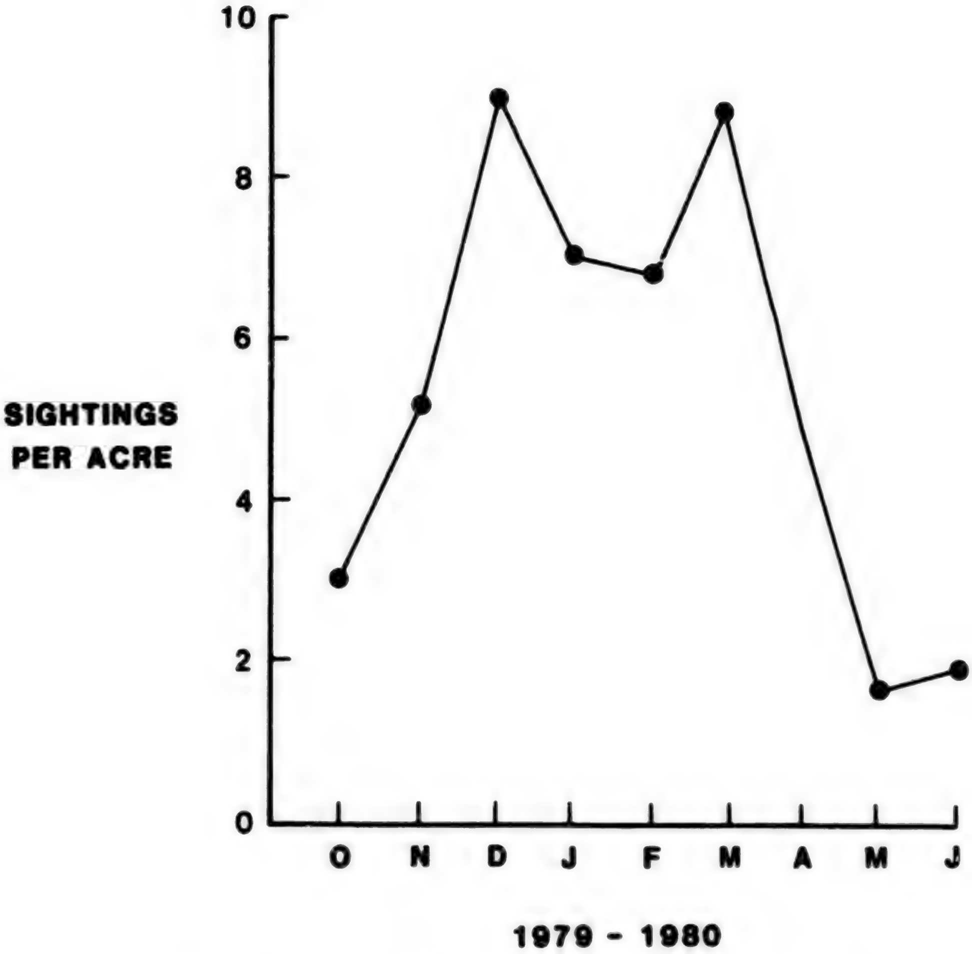

Figure 31. Monthly trends in observed bird densities at observation point viewing areas.

Differences between observation point locations were much more pronounced than the seasonal variations, with 39 percent of the variation in density and 20 percent of the variation in diversity attributable to differences in the habitat charateristics of the viewing areas. The viewing areas ranged from about 2 to 83 acres in size and each had a distinct vegetation pattern and/or setting (Table 25). The most noticeable trend among the viewing areas was the tendency for both density and diversity to peak in areas with an intermediate vegetation coverage. Regression analysis produced significant, quadratic models relating density and diversity to vegetation coverage (Figure 32), and these estimated peak bird use and diversity at about 55 to 60 percent coverage.

The viewing area which had the highest average observed density had a band of open water, about 100 feet across at its widest point, closely bordering the dam. The remainder of the area consisted of patches of cattail and scattered mats of water hyacinth. Several small spoil islands, dominated by saltbush, occurred along the interior border. A spillway structure, which was included in the area of view, maintained the relatively deep, open channel. Ducks, coots, wading birds, red-winged blackbirds, grackles, and gallinules were the predominant species.

Highest diversities were observed at a point overlooking an area of flood stressed willow in relatively deep open water. The willow, which was essentially leafless branches, occupied about half of the area of view. The open water contained a slight amount of duckweed and water hyacinth. Some cattail and healthy willow occurred along the dam. The willow snags were a consistently well utilized roosting habitat for red-winged blackbirds, grackles, wading birds, anhingas and gallinules. Pied-billed grebes, ruddy ducks, coots and cormorants were common feeders in the open water areas.

Areas which had the lowest observed densities and diversities also had low habitat diversities. Lowest densities were recorded from a point overlooking a continuous stand of cattail. Red-winged blackbirds, common yellowthroats and palm warblers were the principle species. Lowest diversities were observed in an area of deep, open water. Through the course of study, double-crested cormorants, and a number of ducks, gulls and swallows were observed, but usually just one or two species were present at each survey.

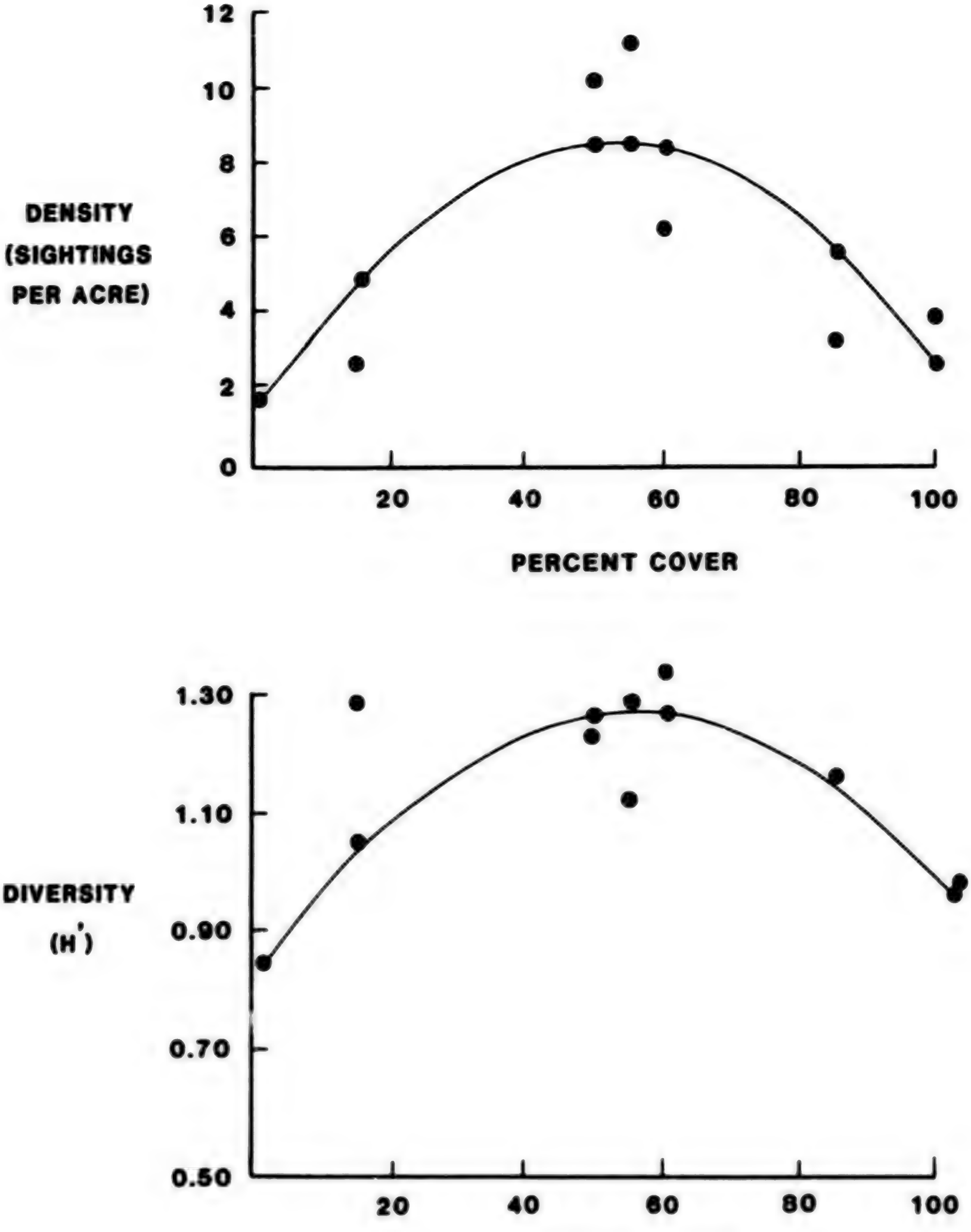

Figure 32. Model predictions and average values for bird density and diversity verses percent vegetation cover within observation point viewing areas.

RECLAMATION CONSIDERATIONS

Growing out of the public's concern for the environment is the realization that wetlands play a vital role in the maintenance of environmental quality. The value of wetlands and the public's desire for their protection and preservation is reflected in strict federal, state, and local regulations. Permits are required for certain types of land uses in wetland areas and important wetlands continue to deserve strong protection due to their benefit to society.

In Florida, a recently enacted rule requires that all mined wetlands be restored to at least their pre-mining surface acreage (Florida Administrative Codes 16C-16). While any wetland cannot be completely "restored" both vegetatively and functionally, certain mitigation measures are highly desirable and possible. The results from this study were encouraging in terms of the ability to establish wetland habitats on mined land. Hopefully, reclaimed wetlands will lead to the re-establishment of diverse, self-maintaining systems in the mining area which will provide the public a variety of useful services, including water storage and flood retention, water treatment, and habitat for fish and wildlife. However, there are a number of wetland community type options and a virtually limitless array of landscape designs, each of which has a unique value to wildlife and to the local drainage area. Optimizing wetlands reclamation will require careful planning and a knowledge of the available options and techniques. Many of the objectives and procedures for reclaiming wetlands as habitat for fish and wildlife were indicated by this study, and are discussed in the following sections.

OBJECTIVES AND PLANNING FOR WETLAND HABITAT

Habitat reclamation should be directed toward maximizing landscape diversity within the constraints imposed by land use. An assortment of community types and a high degree of intermixture, or edge, tends to increase an area's opportunity to attract and support any given species, and will result in a more diverse and sustained level of wildlife use with increased potential for mitigating overall mining related wildlife losses. The establishment of early successional wetland type communities at the Peace River test site was of itself a major improvement in the area's landscape diversity which more than doubled the number of species observed onsite through the course of study (61 percent of the species observed were those usually associated with wetland or aquatic habitats). As the site ages, patches of forest and swamp vegetation should emerge which will further increase the site's landscape diversity and attract new, woodlands oriented wildlife species.

The establishment of diverse community types within a wetland area is an important consideration for improving the habitat value of individual sites. Findings from the clay settling area surveys showed the highest levels of bird use in locations having the greatest degree of wetland community interspersion. Shallow and deep open water areas intermixed with seasonal mud flats, herbaceous emergent zones and shrub swamps, provide alternative feeding areas, escape cover and nesting or roosting habitat for wetland wildlife. Fish populations are also benefitted by access to productive emergent zones, littoral bedding areas and deep water refuges.

Insuring full utilization of areas developed as wildlife habitat may require special measures to increase their accessibility to species with limited dispersal mechanisms. Isolated habitats surrounded by relatively inhospitable land will populate more slowly and may never develop a trophic structure as complete as that in similar habitats interconnected by heavily vegetated travel corridors, or on areas in close proximity to undisturbed land. Levels of wildlife use observed at the wetland test site were a near reflection of the full wildlife potential of that particular site design, since its accessibility was optimized by its close association with the Peace River forest strand.

Wetland habitat reclamation planning also involves the complicated process of designing an appropriate hydrologic setting which will insure each area a proper water supply. The planning unit in this case is the drainage area. It encompasses all areas which will supply or receive water from the wetland basin and is not necessarily restricted to the particular site in question. The delineation of a drainage area is essentially predetermined by the distribution of materials left after mining and waste disposal, and by the site's relationship to local, established drainage patterns. Similarly, the range of habitat design options in each wetland area is constrained to a large extent by the distribution and moisture holding characteristics of soil materials and the desired utilitarian functions of the drainage area.

Wetlands can be situated either above or below the mean water table, and can be either isolated or hydrologically connected to a lake or stream system. Their water will be supplied by ground water seepage and/or by rainfall catchment and surface runoff within the drainage area.

Wetlands perched above the mean water table tend to loose water through soil infiltration and generally will have a more erratic and wider-ranging hydroperiod than a similarly sized basin located closer to or below the average water table. In other words, ground water seepage can compensate for surface water losses due to evaporation and plant transpiration, and thereby moderate the fluctuations inherent in seasonal rainfall patterns. On the wetland test site for example, the water table at the northern end was higher and more stable than on the southern end, probably because of seepage from the unmined ridge to the north. This undoubtedly caused a correspondingly higher ground water contribution to the north basin which contributed to its relatively moderated hydroperiod. Soil permeability, of course, will ultimately affect the rate at which ground and surface waters can be exchanged, and therefore must be considered when planning an area's water budget.

A basin's capacity to collect local storm water runoff is not only affected by the relative permeability of the soil, but is also influenced by the slope and vegetation cover of the drainage area. A rolling or sloped topography in conjunction with sparse or low vegetation and a relatively impermeable, clayey soil will contribute to higher rates of surface runoff. Collection efficiencies at the wetland test site were relatively high (an average of 21 percent of the rainfall received was collected in the basins) reflecting the substantial clay content of its soils (10 percent clay overall), its consistently increasing upslope relief, and the sparse ground cover vegetation. As the site's vegetation continues to develop, the basin's collection efficiency might decrease since forest and shrub vegetation intercepts rainfall and accumulated floor litter tends to restrict surface sheet flow.

A wetland's water supply is also affected by exchanges with contiguous or hydrologically connected lake or stream systems. In turn, the wetland will affect both the quality and supply of water to that lake or stream. Consequently, wetlands have a utilitarian role affecting cultural water supplies which will usually influence the planning decisions for each drainage area. Cultural benefits derived from wetlands include their contributions to water quality by plant nutrient uptake and reduced turbidity caused by their capacity to reduce stream flow, their stabilization of shorelines by buffering wave action, and their capability of reducing floods by retention of storm surges. The wetlands at the test site benefitted the water quality of the Peace River by retaining the turbid waters generated by runoff from the initially exposed soils, and those caused by roadway grading and pipeline construction along the mine road bordering the site to the east.

As these various planning considerations indicate, the development of a final, detailed reclamation plan is highly constrained by the characteristics and setting of each site, and by the land use, habitat and utilitarian roles desired. While there is no "cookbook" which details specific options for each site, there are a number of procedural considerations which have emerged during the term of study which can assist in the development of individual, site-specific plans.

RECLAMATION PROCEDURES

Onsite reclamation activities include earth moving, subsidized revegetation and any follow-up procedures for assisting in the protection and maintenence of the emerging habitats. For wetland areas, basins should be contoured to create the desired wetland surface area within the range of elevations over which the water is expected to fluctuate. Findings from the test site showed that the area dominated by wetland plants did not encompass the entire high-water zone, but instead was restricted to the area between 30 and 83 percent inundation by the end of the second growing season. However, with variations in annual rainfall amounts and continued development of the area's plant communities, virtually all of the zone of fluctuation may eventually support a wetland community.

Accurately predicting the range of surface water level fluctuation can be a difficult planning problem, and a reasonable estimate is the best that can be achieved in many instances. However, on sites where an overflow discharge capability can be arranged, the height of the outfall will establish an interim high water line for the basin and allow for more accurate planning. A temporary control structure would be useful since this would permit necessary adjustments in the basin's storage capacity prior to contouring a permanent, self-maintaining outfall swale.

To promote a diversity of wetland and aquatic community types, and to increase shoreline edge, contours should be varied throughout and below the zone of fluctuation. When utilizing hydrologically connected wetlands to optimize a lake or stream system for fish production, care should be taken to insure that these shallow sub-basins will not become isolated prior to their natural annual drawdown. Deep connecting channels constructed at or below the base elevation of each sub-basin, will insure a continuous water body year-round, and allows the fish population access to deep water refuges during periods of surface water decline. On the other hand, wetlands which become isolated at low water, but which are continuous with permanent water during the wet season, have the capacity to trap and concentrate fish so that they can be readily consumed by birds and other predators. The dual-basin configuration at the test site is typical of the latter situation and was partially responsible for the observed peak bird use during the late fall and early winter months.

After a site is constructed and contoured, passive seed dispersal by wind, water and animal carriers will rapidly establish a vegetation cover and form distinct wetland community types within appropriate inundation zones. Distinguishable upland, transitional and emergent community types developed simultaneously at the test site from local species which passively established themselves within their preferred moisture zones. The entire wetland successional sequence in the clay settling area sites was also established without active subsidy. This capacity for self-revegetation in the central Florida phosphate district is promoted by the area's mild climate, substantial rainfall, diverse native flora and the suitability of the post-mining soils as a growing medium. However, self-dispersal and site compatability are highly species-specific. Furthermore, the number of species which may eventually colonize a site is largely dependent on: (1) the distance of individual sites from a natural seed source; (2) the nearby natural plant community type (marsh, uplands, etc.); and (3) the dispersal mechanism or aggressiveness of the species. Where possible, the location of reclamation sites near native un-mined communities maximizes the potential for re-vegetation by natural plant succession.

The only method of plant subsidy investigated in this study was the transplanting of whole plants or viable plant parts. Other methods which hold promise for habitat reclamation include direct-seeding and mulching with topsoil and litter from a native community (Shuey and Swanson 1979). In planning a planting program, the selection of species should be limited to those which are native to Florida or those which otherwise are particularly valuable food or cover producers. They should also be species which are not expected to quickly colonize a site on their own. Generally, as the distance of a site from the potential seed source or donor community increases, the amount of plant subsidy needed increases. Trees are always likely candidates for planting since their seed production and dispersal mechanisms are generally more deficient than those of herbs or shrubs, and since forest and swamp communities are major contributors to landscape and wetland diversity. Trees selected for planting should include an assortment of conifers and hardwoods which are compatible with the soil conditions onsite. Since the soil conditions on a mine site are different than those of the local native habitats, this assortment may not be the same as that which formerly occurred on the area.

To maximize the distribution of individuals over the planting area, small, easily transported propagules are the most effective. For example, the maidencane rhizome cuttings were a more effective method of propagation than whole plant clumps, and the tree seedlings were more effective than the larger trees. However, for species which are proficient seed producers, planting of whole, mature individuals can be an effective method of providing an onsite seed source. Automation of the labor-intensive planting methods used in the study improves efficiency and reduces reclamation costs. Planting bare-root seedlings, using a tractor-mounted planter; discing tubers, rhizomes and other marsh plant parts; and direct-seeding conifer and hardwood trees using a helicopter or tractor can be useful techniques for habitat establishment projects.

Especially with regard to wetland plantings, establishing the species in its appropriate moisture zone will strongly influence ultimate success. Both the marsh plantings and the wetland seedlings showed a notably variable planting success relative to the inundation zone in which they were established. In instances where the various moisture zones are not adequately predictable at the conclusion of contouring, it may be beneficial to delay the planting effort for a complete growing season to allow the passively established species to indicate appropriate planting areas.

The developing plant communities on new sites should be protected from grazing and mowing. The upland and emergent communities which initially develop have considerably more wildlife value than a pasture or manicured lawn. However, this early successional vegetation has a large percentage of annual herbs and shrubs which can be highly combustible during the dry season. Fire lines should be established and maintained for at least several years to help protect emerging forest and swamp areas from periodic fires which could damage or destroy young trees.

The wildlife characteristics of a settling area are determined by the distribution and successional state of its plant communities which are related to the pattern of sedimentation and the surface water regime imposed by management. Obvious opportunities exist for the development of management strategies targeted for wildlife. It is also conceivable that wetland settings might be permanently established within settling basins in instances where a set, non-subsidized hydrologic regime could be established. However, the settling basin ecosystem at least in its early years, is quite dynamic and subject to dramatic changes in its vegetation characteristics and associated wildlife values. The degree to which an imposed hydrologic regime and associated habitats might persist without human intervention should be thoroughly researched before a wholesale policy of directing above ground basin reclamation toward wetland habitats is embarked upon.

OUTLOOK FOR WETLAND RECLAMATION

This study has demonstrated that wetland habitats can be established on central Florida's phosphate mined land. It also points out that the value of the early successional plant communities which emerge is very much dependent on the planning and procedures used to create them. Continued testing of new options and procedures, and demonstration of these techniques on the full range of possible post-mining substrates should lead to a full elaboration of the technology. However, only when the successional development of an area reaches a point of relative stability can the final evaluation of habitat establishment procedures and the ultimate habitat value of re-created wetlands be made. While long-term implications of wetland reclamation can not yet be assessed, the outlook is promising.

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APPENDIX

Scientific and Common Names of the Animals and Plants Used in the Report

Scientific Name	Common Name
Fish	
Lepisosteus platyrhincus	Florida gar
Dorosoma petenense	threadfin shad
Notemigonus crysoleucas	golden shiner
Ictalurus nebulosus	brown bullhead
Fundulus seminolis	Seminole killifish
Fundulus chrysotus	golden topminnow
Gambusia affinis	mosquitofish
Heterandria formosa	least killifish
Micropterus salmoides	largemouth bass
Pomoxis nigromaculatus	black crappie
Lepomis gulosus	warmouth
Lepomis macrochirus	bluegill
Lepomis microlophus	redear sunfish
Tilapia aurea	blue tilapia
Amphibians	
Siren lacertina	greater siren
Bufo terrestris	southern toad
Bufo quercicus	oak toad
Hyla squirella	squirrel tree frog
Hyla cinerea	green tree frog
Acris gryllus	southern cricket frog
Rana catesbeiana	bullfrog
Rana grylio	pig frog
Rana pipiens	leopard frog
Reptiles	
Kinosternon subrubrum	common mud turtle
Chrysemys floridana	Florida cooter
Chrysemys nelsoni	Florida red-bellied turtle
Trionyx ferox	Florida softshell
Natrix cyclopion	green water snake
Natrix fasciata	banded water snake
Thamnophis sirtalis	common garter snake
Thamnophis sauritus	eastern ribbon snake
Diadophis punctatus	ring-necked snake

Scientific Name	Common Name
Coluber constrictor	racer
Opheodrys aestivus	rough green snake
Drymarchon corais	indigo snake
Elaphe obsoleta	rat snake
Agkistrodon piscivorus	cottonmouth
Sistrurus miliarius	pigmy rattlesnake
Crotalus adamanteus	eastern diamondback rattlesnake
Alligator mississipiensis	American alligator
Birds	
Podiceps nigricollis	eared grebe
Podilymbus podiceps	pied-billed grebe
Pelecanus erythrorhynchos	white pelican
Phalacrocorax auritus	double-crested cormorant
Anhinga anhinga	anhinga
Ardea herodias	great blue heron
Butorides virescens	green heron
Bubulcus ibis	cattle egret
Egretta caerulea	little blue heron
Egretta alba	great egret
Egretta thula	snowy egret
Egretta tricolor	Louisiana heron
Nycticorax nycticorax	black-crowned night heron
Ixobrychus exilis	least bittern
Botaurus lentiginosus	American bittern
Mycteria americana	wood stork
Plegadis falcinellus	glossy ibis
Eudocimus albus	white ibis
Ajaia ajaja	roseate spoonbill
Anas platyrhynchos	mallard
Anas rubripes	black duck
Anas fulvigula	Florida duck (mottled duck)
Anas strepera	gadwall
Anas acuta	pintail
Anas crecca	green-winged teal
Anas discors	blue-winged teal
Anas americana	American wigeon
Anas clypeata	northern shoveler
Aix sponsa	wood duck
Aythya americana	redhead
Aythya collaris	ring-necked duck
Aythya valisineria	canvasback
Aythya affinis	lesser scaup
Oxyura jamaicensis	ruddy duck
Lophodytes cucullatus	hooded merganser

Scientific Name	Common Name
Cathartes aura	turkey vulture
Coragyps atratus	black vulture
Accipiter striatus	sharp-shinned hawk
Buteo jamaicensis	red-tailed hawk
Buteo lineatus	red-shouldered hawk
Haliaeetus leucocephalus	bald eagle
Cirus cyaneus	marsh hawk
Pandion haliaetus	osprey
Falco sparverius	American kestrel
Colinus virginianus	bobwhite
Meleagris gallopavo	turkey
Grus canadensis	sandhill crane
Aramus guarauna	limpkin
Rallus elegans	king rail
Porzana carolina	sora
Gallinula chloropus	common gallinule
Fulica americana	American coot
Charadrius vociferus	killdeer
Capella gallinago	common snipe
Tringa melanoleucus	greater yellowlegs
Tringa flavipes	lesser yellowlegs
Calidris minutilia	least sandpiper
Limnodromus griseus	short-billed dowitcher
Limnodromus scolopaceus	long-billed dowitcher
Recurvirostra americana	American avocet
Himantopus mexicanus	black-necked stilt
Larus delawarensis	ring-billed gull
Larus atricilla	laughing gull
Larus philadelphia	Bonaparte's gull
Gelochelidon nilotica	gull-billed tern
Sterna forsteri	Forster's tern
Sterna hirundo	common tern
Sterna albifrons	least tern
Thalasseus maximus	royal tern
Hydroprogne caspia	Caspian tern
Chilidonias niger	black tern
Rynchops niger	black skimmer
Zenaida macroura	mourning dove
Columbina passerina	ground dove
Coccyzus americanus	yellow-billed cuckoo
Crotophaga ani	smooth-billed ani
Strix varia	barred owl
Chordeiles minor	common nighthawk
Archilochus colubris	ruby-throated hummingbird
Megaceryle alcyon	belted kingfisher
Tyrannus tyrannus	eastern kingbird
Muscivora forficata	scissor-tailed flycatcher
Sayornis phoebe	eastern phoebe

Scientific Name	Common Name
Iridoprocne bicolor	tree swallow
Stelgidopteryx ruficollis	rough-winged swallow
Hirundo rustica	barn swallow
Cyanocitta cristata	blue jay
Corvus brachyrhynchos	common crow
Corvus ossifragus	fish crow
Troglodytes aedon	house wren
Thryothorus ludovicianus	Carolina wren
Telmatodytes palustris	long-billed marsh wren
Cistothorus platensis	short-billed marsh wren
Mimus polyglottos	mockingbird
Dumetella carolinensis	gray catbird
Turdus migratorius	American robin
Polioptila caerulea	blue-gray gnatcatcher
Anthus spinoletta	water pipit
Lanius ludovicianus	loggerhead shrike
Vireo griseus	white-eyed vireo
Dendroica coronata	yellow-rumped warbler
Dendroica palmarum	palm warbler
Geothlypis trichas	common yellowthroat
Dolichonyx oryzivorus	bobolink
Sturnella magna	eastern meadowlark
Agelaius phoeniceus	red-winged blackbird
Cassidix major	boat-tailed grackle
Quiscula quiscula	common grackle
Molothrus ater	brown-headed cowbird
Spinus tristis	American goldfinch
Cardinalis cardinalis	cardinal
Pipilo erythrophthalmus	rufous-sided towhee
Passerculus sandwichensis	savannah sparrow
Pooecetes gramineus	vesper sparrow
Spizella pusilla	field sparrow
Melospiza georgiana	swamp sparrow
Melospiza melodia	song sparrow
Mammals	
Didelphis marsupialis	Opossum
Blarina brevicauda	short-tailed shrew
Dasypus novemcinctus	nine-banded armadillo
Sylvilagus palustris	marsh rabbit
Sylvilagus floridanus	eastern cottontail
Oryzomys palustris	rice rat
Peromyscus gossypinus	cotton mouse
Sigmodon hispidus	hispid cotton rat
Neofiber alleni	Florida water rat
Mus musculus	house mouse
Vulpes vulpes	red fox

Scientific Name	Common Name
Procyon lotor	raccoon
Lutra canadensis	river otter
Mephitis mephitis	striped skunk
Lynx rufus	bobcat
Sus scrofa	pig (wild hog)
Odocoileus virginianus	white-tailed deer
Plants	
Acalypha gracilens	three-sided mercury
Acer rubrum	red maple
Aeschynomene americana	Aeschynomene
Alternanthera philoxeriodes	alligatorweed
Alysicarpus vaginalis	false moneywort
Amaranthus spinosus	spiny amaranth
Ambrosia artemisiifolia	ragweed
Ampelopsis arborea	pepper vine
Andropogon virginicus	beard grass
Aristida sp.	three-awn grass
Aster subulatus	
Azolla caroliniana	mosquito fern
Baccharis halimifolia	salt bush
Bacopa caroliniana	water hyssop
Bidens pilosa	beggar ticks
Brachiaria ramosa	signal grass
Bulbostylis barbata	
Campsis radicans	trumpet vine
Carpinus caroliniana	ironwood
Carya aquatica	water hickory
Carya glabra	pignut hickory
Carya tomentosa	mockernut hickory
Cassia aspera	
Catalpa bignonioides	catalpa
Celtis laevigata	sugar berry
Centella asiatica	coinwort
Cephalanthus occidentalis	buttonbush
Chamaesyce hyssopifolia	
Chenopodium ambrasioides	Mexican-tea
Cladium jamaicense	sawgrass
Comelina diffusa	day flower
Conyza parva	dwarf horseweed
Crotalaria rotundifolia	rattlebox
Croton grandulosus	
Cynodon dactylon	Bermuda grass
Cyperus compressus	sedge
Cyperus distinctus	sedge
Cyperus esculentus	nutgrass
Cyperus globulosus	sedge

Scientific Name	Common Name
Cyperus haspan	sedge
Cyperus iria	sedge
Cyperus retrorsus	sedge
Cyperus surinamensis	sedge
Cyperus stenolepis	sedge
Dactyloctenium aegytium	crowfoot grass
Daucus carota	Queen Anne's lace
Desmodium paniculatum	tick trefoil
Desmodium tortuosum	tick trefoil
Desmodium triflorum	tick trefoil
Digittaria ciliaris	crabgrass
Diospyros virginiana	persimmon
Echinochloa colonum	
Echinochloa muricata	barnyard grass
Echinochloa walteri	
Eclipta alba	
Eichornia crassipes	water hyacinth
Eleocharis cellulosa	spike-rush
Eleucine indica	goose grass
Eupatorium capillifolium	dog fennel
Fimbristylis autumnalis	
Fraxinus caroliniana	pop ash
Fraxinus pennsylvanica	green ash
Gnaphalium falcatum	rabbit tobacco
Gordonia lasianthus	loblolly bay
Heterotheca subaxillaris	camphor weed
Hydrilla verticillata	hydrilla
Hydrocotyl umbellata	water pennywort
Hypericum spp.	St. John's wort
Hyptis verticilatta	bittermint
Ilex glabra	gallberry
Ilex opaca	American holly
Imperata cylindrica	Cogan grass
Indigofera hirsuta	hairy indigo
Impomea trichocarpa	morning glory
Juncus effusus	softrush
Juniperus silicicola	red cedar
Lemna minor	duckweed
Lepidium virginicum	peppergrass
Leptochloa virgata	sprangletop
Lindernia anagallidea	false pimpernel
Liquidambar styraciflua	sweetgum
Ludwigia decurrens	
Ludwigia octovalis	
Ludwigia palustris	
Ludwigia peruviana	primrose willow
Ludwigia repens	

Scientific Name	Common Name
Lupinus diffusus	lupine
Magnolia grandiflora	southern magnolia
Magnolia virginiana	sweetbay
Mullugo verticillata	indian chickweed
Myrica cerifera	wax myrtle
Najas quadalupensis	naiad
Nuphar luteum	spatterdock
Nymphaea spp.	water lily
Nyssa aquatica	tupelo gum
Nyssa biflora	black gum
Oenothera laciniata	evening primrose
Panicum dichotomiflorum	
Panicum hemitomon	maidencane
Paspalum notatum	Bahiagrass
Paspalum repens	torpedo grass
Paspalum urvillei	vasey grass
Persea borbonia	red bay
Phytolacca americana	polkberry
Pinus clausa	sand pine
Pinus elliottii var elliottii	slash pine
Pinus elliotti var densa	south Florida slash pine
Pinus glabra	spruce pine
Pinus palustris	longleaf pine
Pinus taeda	loblolly pine
Pistia stratiotes	water lettuce
Plantago virginica	southern plantain
Platanus occidentalis	sycamore
Pluchea purpurascens	marsh-fleabane
Polygonum punctatum	smartweed
Polypremum procumbens	
Pontederia lanceolata	pickerelweed
Populus deltoides	cottonwood
Potamogeton spp.	pondweed
Prunus serotina	black cherry
Quercus chapmanii	Chapman's oak
Quercus hemisphaerica	laurel oak
Quercus laevis	turkey oak
Quercus myrtifolia	myrtle oak
Quercus nigra	water oak
Quercus virginiana	live oak
Rhynchelytrum repens	natal grass
Richardia scabra	
Rubus trivialis	southern dewberry
Rhynchospora spp.	beak rushes
Sabal palmetto	cabbage palm
Sacciolepsis striata	

Scientific Name	Common Name
Saggittaria lancifolia	arrowhead
Saggittaria latifolia	arrowhead
Salix caroliniana	southern willow
Salvinia rotundifolia	water fern
Scirpus validus	bulrush
Scirpus cubensis	bulrush
Scoparia dulcis	sweet-broom
Serenoa repens	saw palmetto
Setaria geniculata	foxtail grass
Sesbania macrocarpa	
Sida acuta	
Sida rhombifolia	
Smilax bona-nox	greenbriar
Solanum americanum	nightshade
Sochus sp.	sow-thistle
Spartina bakerii	sand cordgrass
Sporobolus poiretii	smut grass
Stillingia sylvatica	Queen's delight
Taxodium ascendens	pond cypress
T. distichum	bald cypress
Thalia geniculata	arrowroot
Typha latifolia	cattail
Ulmus americana var floridana	Florida elm
Urena lobata	Caesar weed
Vaccinium myrsinites	shiny blueberry
Vallisneria americana	tapegrass
Vitis rotundifolia	muscadine grape
Wolffiella floridana	
Xyris ambigua	yellow-eyed grass
Yucca filamentosa	bear-grass

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

The Florida phosphate industry produces about one-third of the world production and more than 75 percent of the phosphate mined in the United States. Intensive strip mining operations used to recover the phosphate ore have had a significant effect on the ecology of central Florida. Approximately 6,500 acres of land are mined each year resulting in the total onsite disruption of existing soils, topography, drainage features, plant communities, and wildlife populations.

Current reclamation land forms are usually simple systems compared to the natural plant communities being mined, and do not restore the habitat values, regional habitat diversity, and some other natural functions normally associated with the pre-mining environment. Of the various habitats lost to mining, none are more critically important to wildlife than wetlands.

This study was an investigation to determine methods of establishing suitable habitat for wetland wildlife on phosphate mined lands.

17. Document Analysis a. Descriptors

Habitats, Phosphate deposits, Reclamation, Wetlands

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group 48B

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